

BELLCOMM, INC.

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SUBJECT: Feasibility of a Marius Hills
Mission in the Period From
July Through October 1971 -
Case 310

DATE: December 24, 1969

FROM: D. R. Anselmo

ABSTRACT

Hybrid trajectory missions with a DPS abort capability are feasible from July through October 1971 for a spacecraft injected weight up to 107,000 lbs. November ΔV requirements preclude a mission to Marius Hills.

The strategy that allows missions in September and October requires an early return to earth in the event of a LM rescue by the CSM. If rescue is not performed, the ΔV allotment for the rescue maneuver is used to extend the orbital stay to three days after ascent for lunar orbital science. Missions in September and October would require a reduction in the contingency ΔV allowance from 1000 fps to 800 fps if the spacecraft weights reach control weight values.

The feasibility of this sequence of mission opportunities provides flexibility to respond to late lunar roving vehicle readiness. The first lunar roving vehicle is scheduled for delivery to KSC on April 1, 1971, which supports the nominal launch date of July 30, 1971 for the Marius Hills mission.

(NASA-CR-112555) FEASIBILITY OF A MARIUS
HILLS MISSION IN THE PERIOD FROM JULY
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MEMORANDUM FOR FILE

The current schedule for delivery of the first lunar roving vehicle (LRV) to KSC is April 1, 1971. This will support a launch date of July 30, 1971. To provide for the possibility of a late LRV delivery, the feasibility of a mission to Marius Hills (which depends on the LRV availability) in the period of July through October has been examined. The missions considered retain the hybrid trajectory profile, DPS abort constraint and Pacific injection.

The present contingency allowance in the SPS ΔV budget includes 900 fps for LM rescue. This requirement is root sum squared with a 500 fps allowance for earth landing zone weather avoidance and a 150 fps allowance for doing transearth injection (TEI) with back-up guidance, which yields a total contingency allowance of 1040 fps (1000 fps is actually used). The total mission independent budget employed is given in Table 1.

The maximum allowable spacecraft injected weight was first determined on the basis of spacecraft propulsion capability only. This answers the question: given a usable propellant quantity of 39,550 lbs. and a LM weight of 36,110 lbs.*, what is the CSM weight that will require the entire propellant available? Both the mission dependent and mission independent ΔV requirements are considered. For a given set of mission ΔV requirements the allowable spacecraft injected weight as determined by SPS capability can exceed a launch vehicle injected payload capability of 107,000 lbs. For the proposed control weight spacecraft (Table 2) full SPS tanks result in an injected weight of 107,000 lbs. As a result, for cases where allowable injected weight exceeds 107,000 lbs. a control weight spacecraft flown with full tanks yields a positive SPS fuel reserve above the requirements.

*This LM weight is 40 lbs. below the APO proposed control weight, which keeps spacecraft injected weight at 107,000 lbs.

Hybrid missions were targeted for various post-rendezvous orbital stay times. Missions in September and October with proposed control weight spacecraft (Table 2) are not feasible with a three-day orbital science stay after rendezvous if the full contingency ΔV allowance is required. However, a new strategy is suggested. In the event a LM rescue is required, an early return to earth (after four lunar orbits) would be performed. This is possible since the TEI ΔV cost for Marius Hills decreases as lunar orbital stay time is decreased as illustrated in Figure 1. By employing an early TEI following a rescue, a mission is feasible in September with J2 current weights (Reference 2) as shown in Figure 2.

Figure 3 illustrates the contingency ΔV available for a Marius Hills mission in the period from July through October. In September and October the available contingency ΔV is below the present allocation, however the use of an eight-hour post-ascent stay would result in a minimum contingency ΔV of 800 fps for an October mission. If a LM rescue were not required and the orbital stay time post-ascent was then extended to three days, the contingency ΔV available for back-up TEI and weather avoidance would be 760 fps in September and 320 fps in October.

Trajectory data for these missions has been included in Table 3. Relaxation of the DPS abort constraint for the nominal mission in September would not reduce the spacecraft SPS ΔV requirements since the optimum trajectory does not require the full DPS abort ΔV available.

The feasibility of a mission in November 1971 was examined and it was found that, even with current J2 weights and deletion of the 1000 fps contingency allowance, the mission was not possible.

In the period examined launch vehicle energy requirements are always below the reference capability of $-8.06 \times 10^6 \text{ ft}^2/\text{sec}^2$ plus 32.8 fps of flight geometry reserves. The reduced energy requirement translates into a reduced TLI velocity requirement that ranges from 53 fps in July to 73 fps in October. Using a sensitivity of 10 lbs. payload per fps and including 23 fps of the FGR*, the payload increase ranges from 750 lbs. in July to 960 lbs. in October. In practice this delta could be used to offset the need for a launch window reduction or restriction to first injection opportunity.

*The FGR allowance of 32.8 fps (10 meters/second) includes 23 fps for Earth-Moon geometry variation, which may be applied to payload once the specific energy requirements for a mission are determined.

CONCLUSIONS

A Marius Hills mission is feasible with a control weight spacecraft in the period from July through October 1971. In September and October an early return to Earth would have to be performed in the event of a LM rescue. In order to provide the full three-day orbital science part of the contingency allowance must be used for TEI. For a control weight spacecraft the contingency budget would have to be reduced to 800 fps to allow early return in September and October. If spacecraft weights do not grow to the 107,000 lb. injected weight assumed, SPS ΔV reserves will, of course, be greater than those shown.



D. R. Anselmo

2013-DRA-jab

Attachments:

Tables 1 through 3

Figures 1 through 3

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REFERENCES

1. Letter from Apollo Program Director to MSC and MSFC;
Specification for Apollo 16 and Subsequent, October 24,
1969.
2. Apollo Spacecraft Configuration Weight and Performance
Summary, December 15, 1969, MSC Monthly Weight Report.

TABLE I

Mission Independent ΔV Budget

ΔV Pre LM Separation

Translunar and LOI Dispersion Allowance	120 fps
SPS DOI Maneuver	75 fps
Conic Calibration	<u>35 fps</u>
Total	230 fps

ΔV Post LM Separation

Post DOI Circularization	75 fps
Conic Calibration	50 fps

Contingencies

LM Rescue	900	
Weather Avoidance	500	
SCS TEI	<u>150</u>	<u>1000 fps</u>

RSS \approx 1000

Total	1125 fps
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TABLE 2

SPACECRAFT WEIGHTS (LBS.)

CM Inert*	13,000
SM Inert*	12,800
SM Science*	750
SLA*	4,150
LM Including 850 lb. Science Payload***	36,110
SPS Unusable Propellant**	640
SPS Usable Propellant	<u>39,550</u>
	107,000
DPS Usable Propellant	18,800

*Proposed control weights (Reference 1)

**Dispersion and malfunction allowance

***Proposed control weight LM is 36,150
which includes 1000 lbs. of LM science.
36,110 used to keep injected weight at
107,000 lbs. maximum.

TABLE 3

SUMMARY OF TRAJECTORY DATA FOR MARIUS HILLS MISSIONS
(54-HOUR SURFACE STAY FOR ALL MISSIONS)

Launch Date	Pre-Descent Orbits	Post-Ascent Orbits	Free Return Perilune Altitude-N.Mi.	ΔV Hybrid	ΔV LOI	ΔV Plane Chg.	ΔV TEI	ΔV DPS Abort	Sun Elev.
7/30/71	11.5	36	2650	33.7	2705	7.6	2713	1975	10
8/28/71	16.5	36	1500	22.7	2815	7.6	2795	1490	6
9/27/71	11.5	36	1400	20.6	2904	7.5	2906	1431	7
10/27/71	11.5	36	1800	38.6	2859	7.2	3408	1978	14
7/30/71	11.5	4	2650	33.7	2705	7.6	2677	1975	10
8/28/71	16.5	4	1500	22.7	2815	7.6	2713	1490	6
9/27/71	11.5	4	1400	20.6	2904	7.5	2812	1431	7
10/27/71	11.5	4	1800	38.6	2859	7.2	2918	1978	14

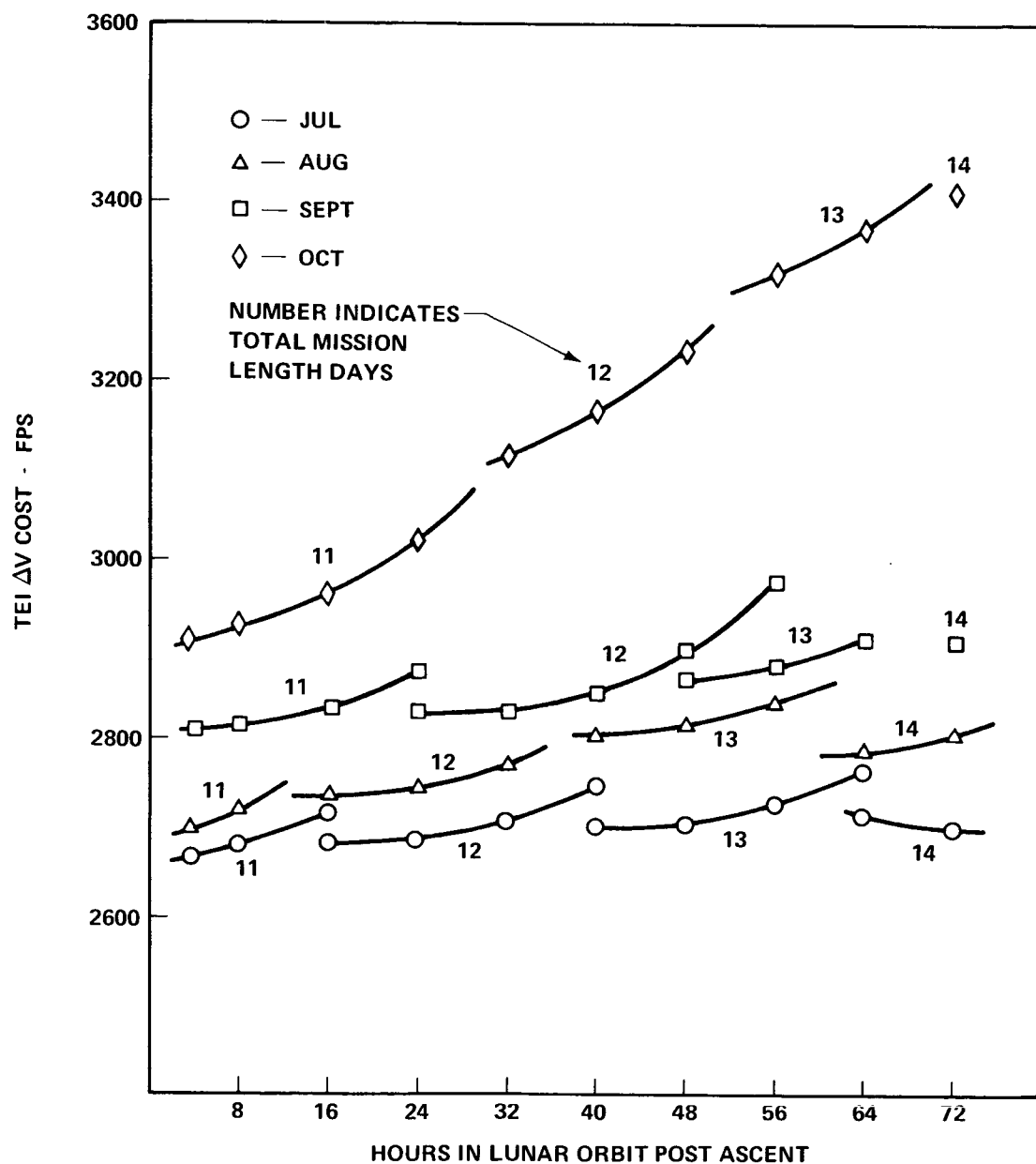


FIGURE 1 — EFFECT OF POST ASCENT LUNAR STAY ON TEI ΔV COST

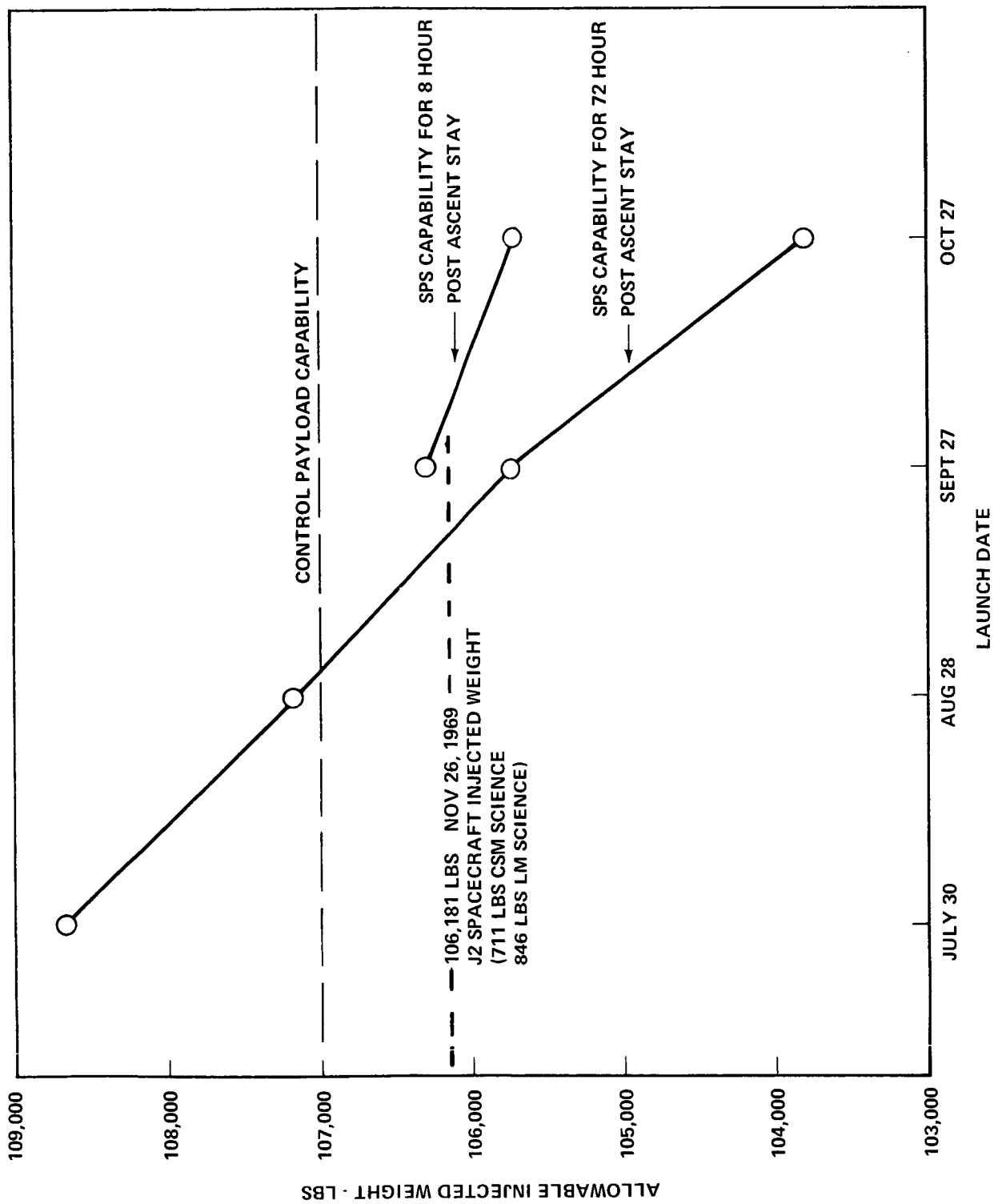


FIGURE 2 - MAX SPACECRAFT INJECTED WEIGHT BASED ON MAX SPS USABLE PROPELLANT AND FULL ΔV BUDGET REQUIREMENTS

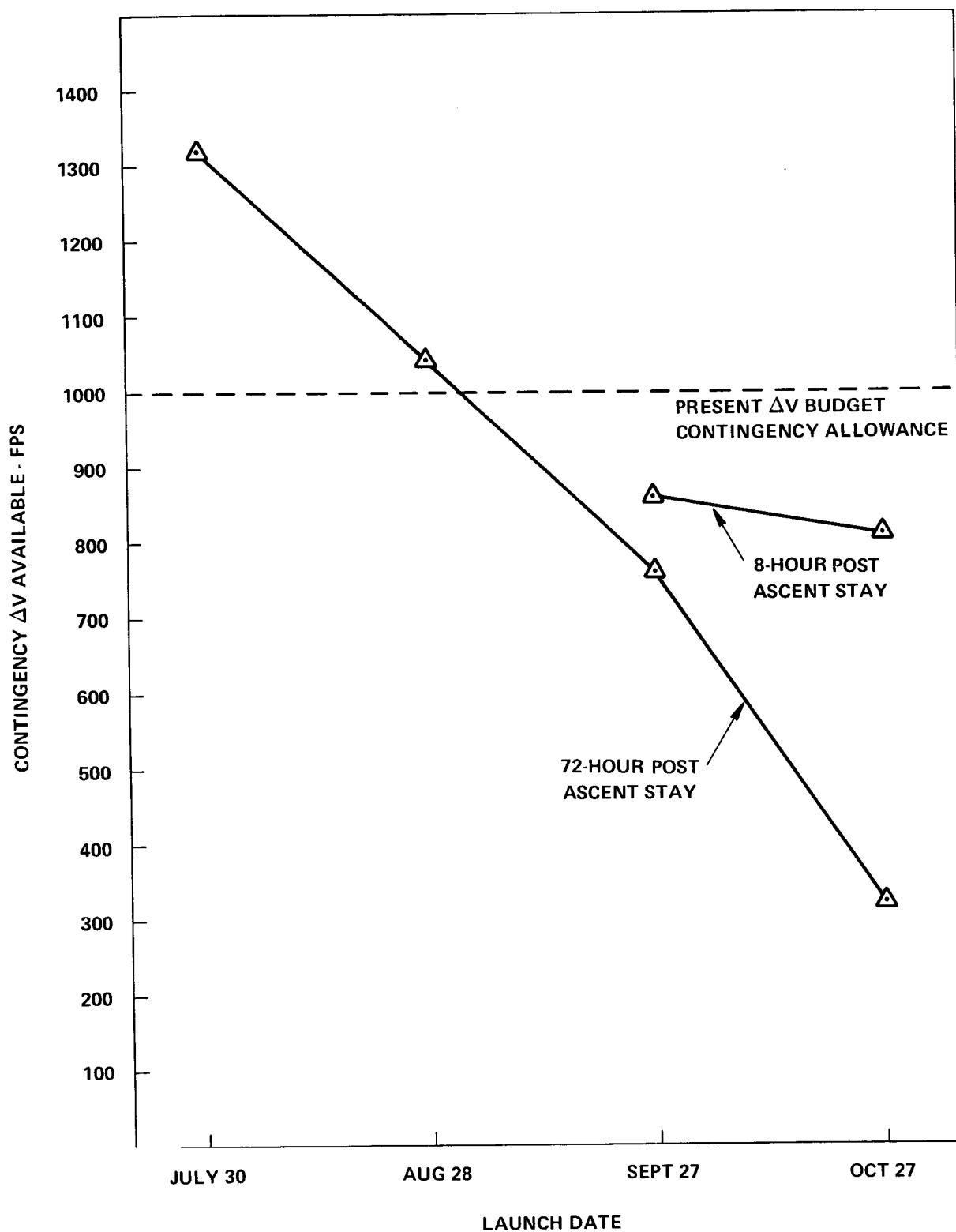


FIGURE 3 - CONTINGENCY ΔV AVAILABLE USING THE PROPOSED CONTROL WEIGHT SPACECRAFT

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